

## Walter Lewin Questions

1. If a ball is thrown vertically up by a person sitting in the **moving** car then ball will have a projectile motion and horizontal distance covered by ball will be same as that of person.

2. If a ball is thrown towards the monkey hanging on the wall with an angle that the straight line (with end points as starting point and the centre of monkey) has with the horizontal at any velocity then the ball will always hit the monkey provided that the velocity should be sufficient enough to cover the horizontal distance between the starting point of ball and monkey.

3. Derivation of centripetal acceleration,  
 $a = (\omega^2) * r$

4. As gravity is not present in space. So, we provide artificial or perceived gravity by rotating the space station.

5. Centrifugal separator ka concept aur unka free surface tube ke andar horizontal nhi vertical hota h

6. Centripetal acceleration is normally much higher than acceleration due to gravity i.e. we can neglect  $g$ .

7. Newton's laws of motion can not be proved because its impossible to be sure that your reference frame is without any acceleration.

8. If speed of a object is greater than speed of light then newton laws will not work and we have to use einstein theory of special relativity.

9. If a ball of mass  $m$  falls from height  $h$  then during its movement earth also comes closer to it by a distance  $d$  and if the ball is thrown upto height  $h$  from surface of earth then the earth also moves away from the ball by distance  $d$ .

$$m \cdot g = M \cdot a$$

where  $M$  is mass of earth

$a$  is acceleration of earth

$$d = 0.5 \cdot a \cdot (t^2) \text{ and } t^2 = (2 \cdot h) / g$$

$$\text{As } M \gg m \gg a \ll g \gg d \sim 0$$

Thus, we can say that earth shakes or vibrates (though very very little) during movement in favour of or against gravity.

10. Friction creates problem in most of the engineering applications because it consumes some part of useful power that we want and friction force is also not conservative(i.e. depends on path. So, can consume more power than the minimum power it should consume). Best way of **reducing friction** between two surfaces is by **developing a thin film of air or gas** between the surfaces because air or gas has very low coefficient of friction. Best way of doing this is **by taking dry ice** in a vessel, make a **small hole at bottom** of vessel and put the desired object over the vessel. As the dry ice vessel is very cold from inside(because dry ice **directly sublimates at  $-78.5^{\circ}\text{C}$  and atm. pressure**). So, it starts sublimating when kept in ambient atmosphere. So, its pressure will increase and will come outside from bottom hole. Thus, making a thin layer of  $\text{CO}_2$  gas between the surface and vessel. In this way friction can be almost(not equal to) decreased down to zero **without the use of any power source** which supplies pressure to make this thin layer.



11. Derivation of work energy theorem for 1-D and for 3-D i.e. net work done = change in K.E. Also, work energy theorem can be applied to any body whether forces acting on it are conservative or non conservative.

12. Mechanical energy is only conserved when the forces acting on it are conservative. A conservative force is one whose work done is independent of path and depends only on end points. Like gravity force and spring force are conservative because their l.o.a. always remain in one direction but friction force is not a conservative force because friction force will always be tangent to the surface and its direction will change.

13. Think that roller coaster case and prove  
 $H = 2.5R$

14. Why air bubble formed at the surface when you drop a smooth spherical ball inside it

15. Force will always be in the direction that opposes the increase in potential energy like gravity force, spring force etc.

$$dU/dx = -F$$

16. Potential energy of a body when it is brought from infinity to a point at a distance of 'r' from centre of earth =  $-(G*M*m)/r$

» Exact change in P.E. when we throw an object upto certain height h (~in metres) from surface of earth =  $[(-(G*M*m)/(R+h)) - (-(G*M*m)/R)] = [(G*M*m*h)/(R*(R+h))] \sim m*(G*M/R^2)*h = mgh$

17. Derive vertical rocket equation i.e.

Thrust force =  $ma = m*(dv/dt) = u*(dm/dt) - g*t$   
where v is velocity of rocket and u is relative velocity of exhaust w.r.t. rocket

And also derive

$$v_2 - v_1 = u * \ln(m_2/m_1) - g*t$$

18. K.E. can be destroyed but momentum can't be destroyed in the absence of net external force on the system as a whole and also all the K.E. of centre of mass of two bodies moving in opposite direction becomes zero or converted into heat during inelastic collision.

19. Derivation of parallel axis theorem and perpendicular axis theorem

20. If we want to save energy while driving an automobile then we should use flywheel so that when we have to decrease speed then rotational K.E. of wheels is converted into rotational K.E. of flywheel which can be used again to give energy to automobile for any purpose instead of applying brakes to decrease speed of automobile (as all the K.E. is converted into heat energy in case of brakes).

Also, if we have to go downhill then also P.E. of automobile can be converted into rotational K.E. of flywheel which can be used again to move the automobile uphill or any other purpose (as in case of brakes we require surplus energy for moving uphill or other purpose).

21. Why size of sun increases?

22. Prove  $dL/dt = r \times (dp/dt) = r \times (\text{External Force})$   
 $= I\omega = \text{External Torque}$



23. If a rotating body is **pivoted about its centre of mass** then net force acting on it is zero and its angular momentum will remain **conserved about any point taken in space** but if the rotating body is **pivoted about any point other than centre of mass** then net force acting on it will be non zero and its angular momentum will be only **conserved about pivoted point & not any other point in space.**

Angular momentum about centre of mass = spin angular momentum

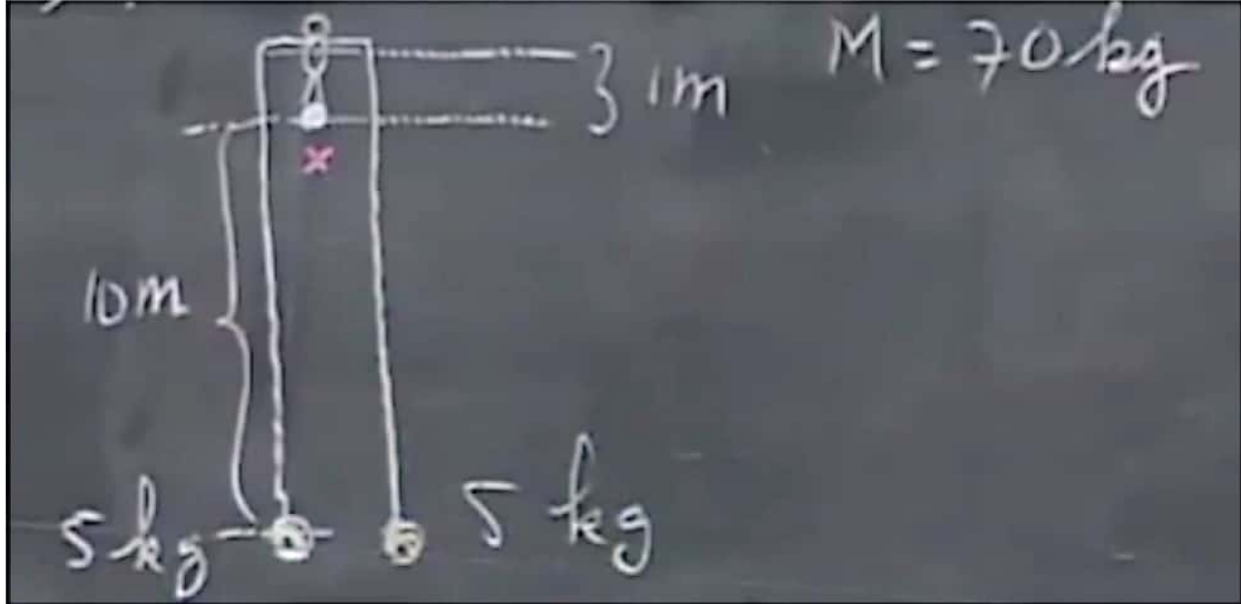
24. Vo lec 21 me vertical bar ko impulse diya tha aur angular velocity nikalni thi do tareeko se i.e. torque ko do point ke about lw se equate karke

25. We can find centre of mass of any body may be uniform or non uniform of any shape by the principle that centre of mass will always be on the vertical line that passes through point of suspension i.e. pivot the body about any two points and make the vertical lines that passes through the pivoted point. Thus, centre of mass will be the point of intersection of that two vertical lines.

26. A person walking on rope make the arrangements in such a way that the combined centre of mass always comes below the rope and he will remain in stable equilibrium (because in below case gravity force will act as a restoring couple) just as shown in figure.



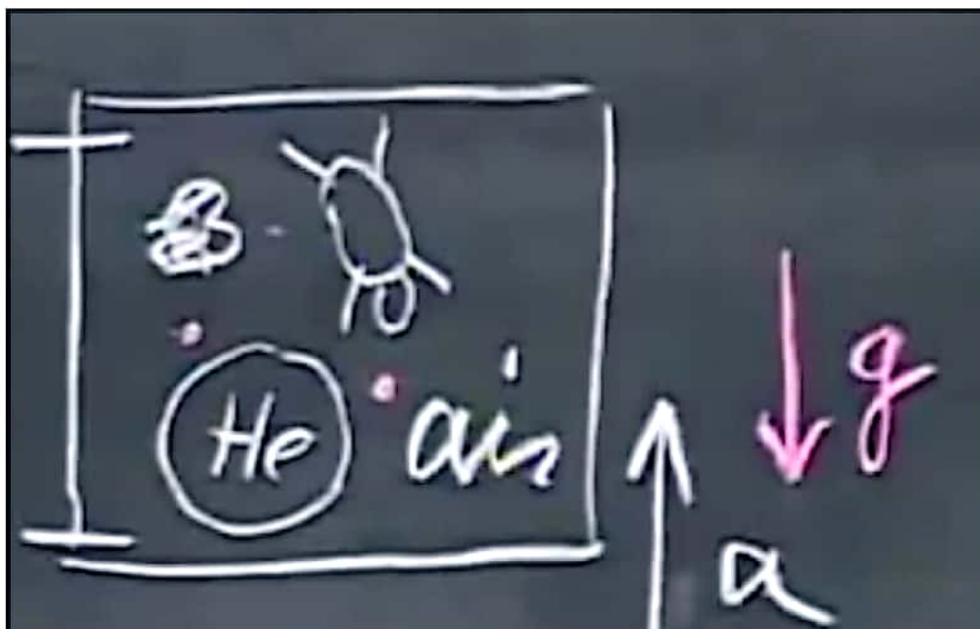




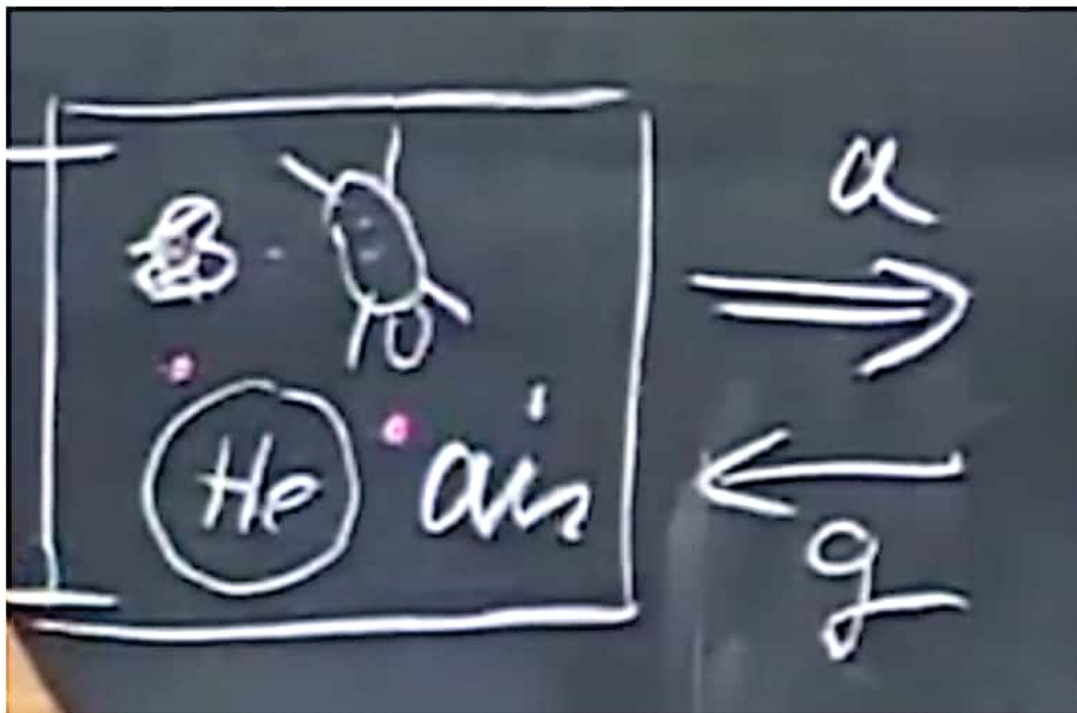
In this figure the pink cross will be the combined centre of mass.

27. As net buoyant force acting on a hot air balloon of Helium is in upward direction (because buoyant force of air is greater than weight of helium) so we can say that balloon will move in direction opposite to direction of gravity or net acceleration.

Based on this concept following three figures can be justified.



This figure corresponds to a container (containing an apple, a person, a balloon and air in it) which have a acceleration ' $a$ ' in upward direction in space. So, perceived gravity( $=a$ ) will be in downward direction. Thus, apple & person will fall downwards and the balloon will move up.

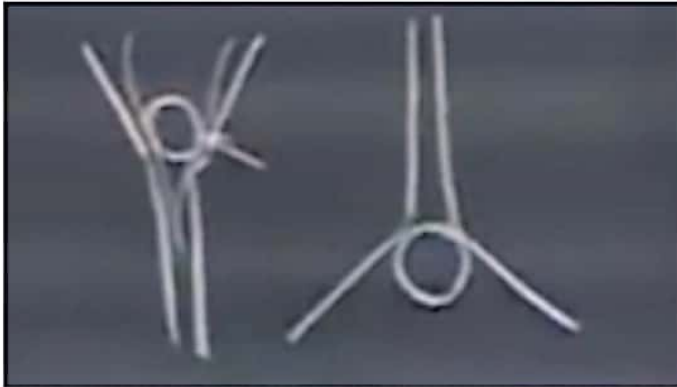


This figure corresponds same as above figure with only difference that acceleration in this case is in horizontal direction. So, apple & person will move backwards and balloon will move forward.

» If **air is not present** inside the container in above two cases then **balloon will also go in the same direction as that of apple & person** because there will be no buoyant force on balloon in that case & movement of balloon will be guided by its own weight.

» Another illustration of the above case (with air inside) is when you are travelling in car with a He balloon hanging in the car then on applying brakes all of us will go in forward direction but balloon will go in backward direction.

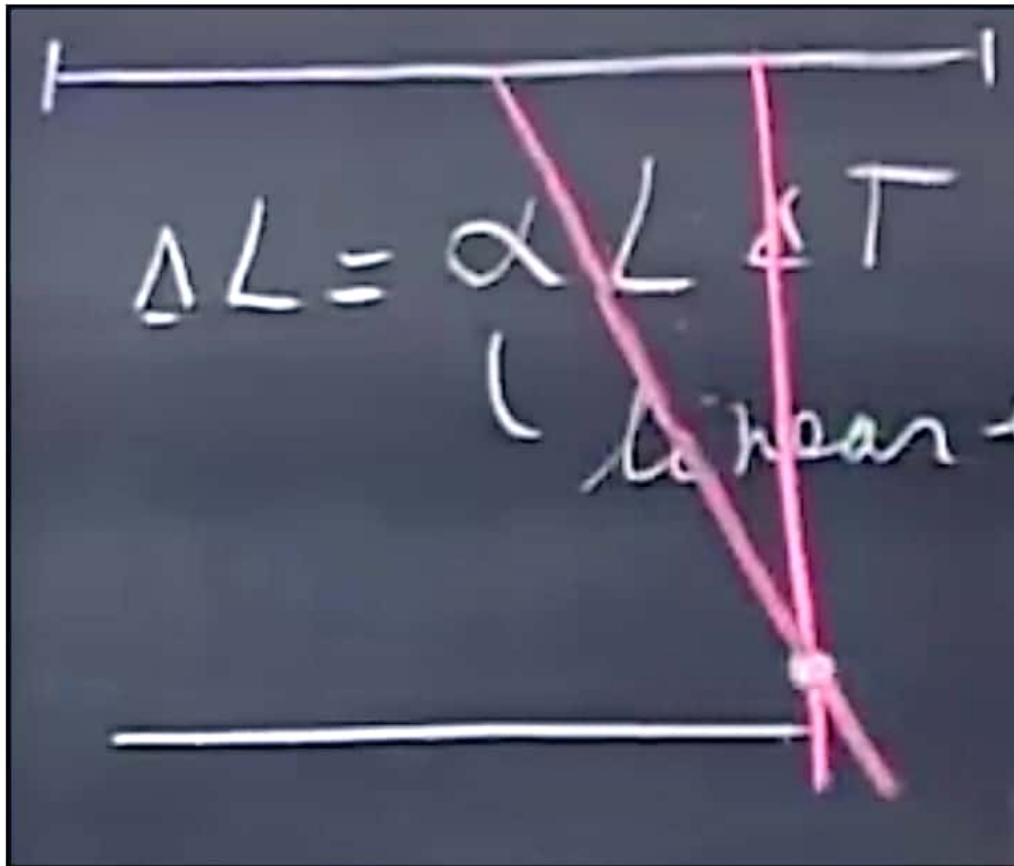
28.



In the figure shown, a ball is placed at the throat of a V-shaped funnel when the funnel is in upward and downward position. If we blow air at high velocity inside the funnel from the lower diameter side end in both cases then the ball will remain in the same position (rather little bit suck towards lower diameter side) in both cases because velocity will be high around the periphery of ball (i.e. the clearance between ball and funnel through which air passes to other side) & in lower diameter section so pressure will be low around the periphery and in the small diameter section. Thus, the ball will try to move to low pressure side.

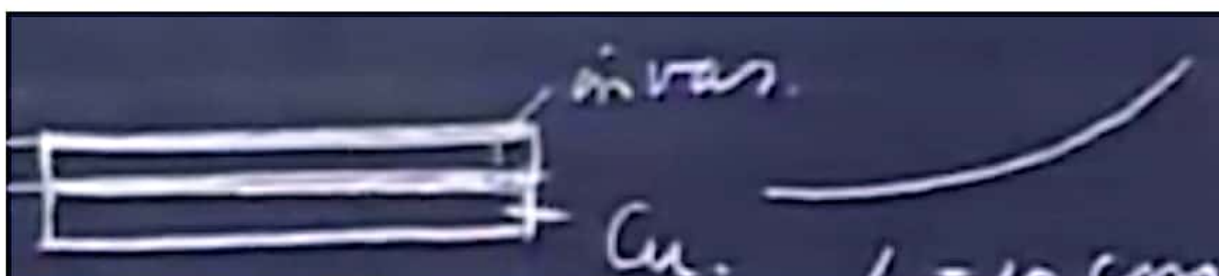


29. One of the good way of amplifying a certain distance (like fraction of mm) is shown below

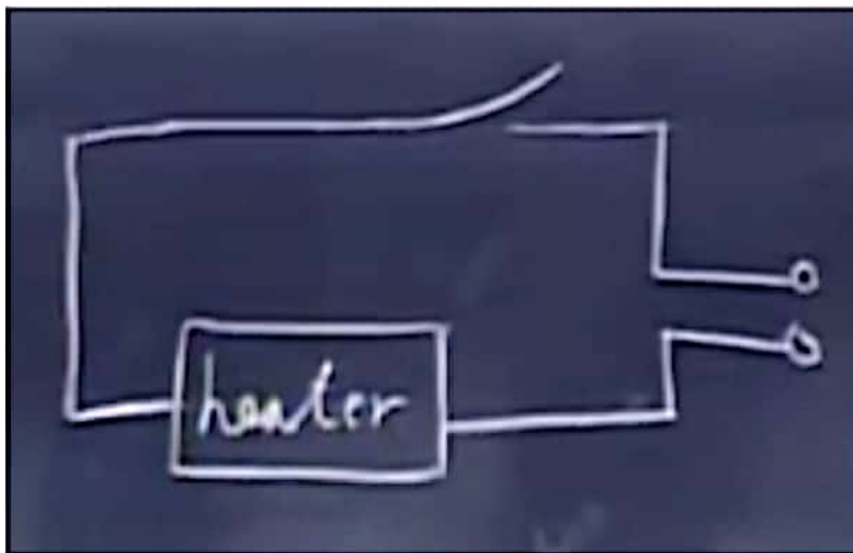


Here we can measure the increase in length of lower white rod by hinging a vertical red rod at a small distance from the free end of lower white rod. Another side or red rod is made so large that we can easily determine the horizontal displacement of the upper end point of red rod.

30.



The figure corresponds to a bi-metal strip in which two strips of different coefficient of thermal expansion ( $Cu > Invar$ ) are joined such that no slipping takes place between the surfaces in contact. If there is increase in temperature then the bi-metal strip will bent in a shape as shown. This concept is used in gas type water heaters used in homes or other places and also while making coffee.



This is a typical diagram of gas type water heater. When the temperature of water is sufficiently high then bi-metal strip becomes curved and circuit breaks. Thus, stopping current supply so that no further heating of water takes place. And when the temperature drops then again the bi-metal strip try to become horizontal and circuit completed. Thus, heating the water again.



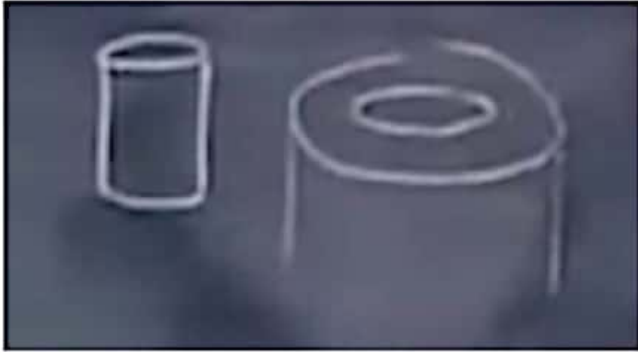
**This is the hole.**

This diagram corresponds to process while making a coffee. Firstly the water is heated in the vessel and when the temperature is sufficiently high then the bi-metal strip becomes curved and water moves through the hole in other vessel where coffee powder is present. Though the process is not so economical as compared to normal process but it teaches us another use of bi-metal strip.

» So, based on this concept we can say that a strip or rod can effectively becomes shortened (as the main aim for curving the strip is to reduce its horizontal length such that the contact breaks) with increase in temperature through the use of bi-metal strip.



### 31. Shrink Fitting



In shrink fitting, we heat hollow cylindrical rod so that it expands and put the smaller diameter rod inside the hollow so that when the rod cools, it will contract and we have interference fit between them.

32. As density of water is maximum at  $4^{\circ}\text{C}$ , so when water lake freezes then water with maximum density will be at the bottom position. So, temperature of bottom layer of an ice lake is  $4^{\circ}\text{C}$  and fishes can easily survive there.